APPENDIX R
STRAWBALE CONSTRUCTION

(Note: As submitted to the International Code Council (ICC) on 1.3.13, for proposed inclusion in the 2015 International Residential Code (IRC). Use of this document without written consent of its lead author Martin Hammer, and the ICC is prohibited. For inquiries or comments, please contact Martin Hammer at mfhammer@pacbell.net)

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

SECTION AR101
GENERAL

AR101.1 Scope. This appendix provides prescriptive and performance-based requirements for the use of baled straw as a building material. Other methods of strawbale construction shall be subject to approval in accordance with Section 104.11 of the International Residential Code.

SECTION AR102
DEFINITIONS

AR102.1 Definitions. The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the International Residential Code for general definitions.

BALE. Equivalent to straw bale.

CLAY. Inorganic soil with particle sizes less than 0.00008 in. (0.002 mm) having the characteristics of high to very high dry strength and medium to high plasticity.

CLAY SLIP. A suspension of clay particles in water.

FINISH. Completed compilation of materials on the interior or exterior faces of stacked bales.

FLAKE. An intact section of compressed straw removed from an untied bale.

LAID FLAT. The orientation of a bale with its largest faces horizontal, its longest dimension parallel with the wall plane, its ties concealed in the unfinished wall and its straw lengths oriented across the thickness of the wall.

MESH. An openwork fabric of linked strands of metal, plastic, or natural or synthetic fiber, embedded in plaster.

NONSTRUCTURAL WALL. All walls other than load-bearing walls or shear walls.

ON-EDGE. The orientation of a bale with its largest faces vertical, its longest dimension parallel with the wall plane, its ties on the face of the wall, and its straw lengths oriented vertically.

PIN. A vertical metal rod, wood dowel, or bamboo, driven into the center of stacked bales, or placed on opposite surfaces of stacked bales and through-tied.

PLASTER. Gypsum, lime, cement-lime, or cement plasters, as defined in Chapter 25 of the International Building Code and in Section AR104, or clay plaster as defined in Section AR104.4.3, or soil-cement plaster as defined in Section AR104.4.4.

PRE-COMPRESSION. Vertical compression of stacked bales before the application of finish.

REINFORCED PLASTER. A plaster containing mesh reinforcement.
RUNNING BOND. For the purposes of this appendix, the placement of straw bales such that the head joints in successive courses are offset at least one quarter the bale length.

SHEAR WALL. A strawbale wall designed to resist lateral forces parallel to the plane of the wall in accordance with Section AR106.16.

SKIN. The compilation of plaster and reinforcing, if any, applied to the surface of stacked bales.

STRUCTURAL WALL. A wall that meets the definition for a load-bearing wall or shear wall.

STACK BOND. For the purposes of this appendix, the placement of straw bales such that head joints in successive courses are vertically aligned.

STRAW. The dry stems of cereal grains after the seed heads have been removed.

STRAW BALE. A rectangular compressed block of straw, bound by ties.

STRAWBALE. The adjective form of straw bale.

STRAW-CLAY. Loose straw mixed and coated with clay slip.

TIE. A synthetic fiber, natural fiber, or metal wire used to confine a straw bale.

TRUTH WINDOW. An area of a strawbale wall left without its finish, to allow view of the straw otherwise concealed by its finish.

SECTION AR103
BALES

AR103.1 Shape. Bales shall be rectangular in shape.

AR103.2 Size. Bales shall have a minimum height and thickness of 12 inches (305 mm), except as otherwise permitted or required in this appendix. Bales used within a continuous wall shall be of consistent height and thickness to ensure even distribution of loads within the wall system.

AR103.3 Ties. Bales shall be confined by synthetic fiber, natural fiber, or metal ties sufficient to maintain required bale density. Ties shall be at least 3 inches (76 mm) and not more than 6 inches (152 mm) from bale faces and shall be spaced not more than 12 (305 mm) inches apart. Bales with broken ties shall be retied with sufficient tension to maintain required bale density.

AR103.4 Moisture content. The moisture content of bales at the time of application of the first coat of plaster or the installation of another finish shall not exceed 20 percent of the weight of the bale. The moisture content of bales shall be determined by use of a moisture meter designed for use with baled straw or hay, equipped with a probe of sufficient length to reach the center of the bale. At least 5 percent and not less than ten bales used shall be randomly selected and tested.

AR103.5 Density. Bales shall have a minimum dry density of 6.5 pounds per cubic foot (92 kg/cubic meter). The dry density shall be calculated by subtracting the weight of the moisture in pounds (kg) from the actual bale weight and dividing by the volume of the bale in cubic feet (cubic meters). At least 2 percent and not less than five bales to be used shall be randomly selected and tested on site.

AR103.6 Partial bales. Partial bales made after original fabrication shall be retied with ties complying with 103.3.

AR103.7 Types of straw. Bales shall be composed of straw from wheat, rice, rye, barley, or oat.

AR103.8 Other baled material. The dry stems of other cereal grains or grasses shall be acceptable when approved by the building official.
SECTION AR104
FINISHES

AR104.1 General. Finishes applied to strawbale walls shall be any type permitted by the International Residential Code, and shall comply with this section and Chapters 3 and 7 of the International Residential Code unless stated otherwise in this section.

AR104.2 Purpose, and where required. Strawbale walls shall be finished so as to provide mechanical protection, fire resistance, protection from weather, and to restrict the passage of air through the bales, in accordance with this appendix and the International Residential Code.

Exception: Truth windows shall be permitted where a fire-resistant rating is not required. Weather-exposed truth windows shall be fitted with a weather-tight cover.

AR104.3 Vapor retarders. Class I and Class II vapor retarders shall not be used on a strawbale wall, nor shall any other material be used that has a vapor permeance rating of less than 5 perms, except as permitted or required elsewhere in this appendix.

AR104.4 Plaster. Plaster applied to bales shall be any type described in this section, and as required or limited in this appendix.

AR104.4.1 Plaster and membranes. Plaster shall be applied directly to strawbale walls to facilitate transpiration of moisture from the bales, and to secure a mechanical bond between the skin and the bales, except where a membrane is allowed or required elsewhere in this appendix.

AR104.4.2 Lath and mesh for plaster. The surface of the straw bales functions as lath, and no other lath or mesh shall be required, except as required for out-of-plane resistance by Table 105.4, or for structural walls by Table AR106.14 and Table AR106.16.

AR104.4.3 Clay plaster. Clay plaster shall comply with AR104.4.3.1 through AR104.4.3.6.

AR104.4.3.1 General. Clay plaster shall be any plaster having a clay or clay-soil binder. Such plaster shall contain sufficient clay to fully bind the plaster, sand or other inert granular material, and shall be permitted to contain reinforcing fibers. Acceptable reinforcing fibers include, chopped straw, sisal, and animal hair.

AR104.4.3.2 Lath and mesh. Clay plaster shall not be required to contain reinforcing lath or mesh except as required in Table AR105.4 and Table AR106.15. Where provided, mesh shall be natural fiber, corrosion-resistant metal, nylon, high-density polypropylene, or other approved material.

AR104.4.3.3 Thickness and coats. Clay plaster shall be a minimum 1 inch (25 mm) thick, unless required to be thicker for structure, as described elsewhere in this appendix, and shall be applied in not less than two coats.

AR104.4.3.4 Rain-exposed. Clay plaster, where exposed to rain, shall be finished with lime wash, linseed oil, or other approved erosion-resistant finish.

AR104.4.3.5 Prohibited finish coat. Cement plaster shall not be permitted as a finish coat over clay plasters.

AR104.4.3.6 Plaster additives. Additives shall be permitted to increase plaster workability, durability, strength, or water resistance.

AR104.4.4 Soil-cement plaster. Soil-cement plaster shall comply with AR104.4.4.1 through AR104.4.4.3.

AR104.4.4.1 General. Soil-cement plaster shall be comprised of soil (free of organic matter), sand, and not less than 10% Portland cement by volume, and shall be permitted to contain reinforcing fibers.

AR104.4.4.2 Lath and mesh. Soil-cement plaster shall use any corrosion-resistant lath or mesh permitted by the International Building Code, or as required in Section AR105 where used on a structural wall.

AR104.4.4.3 Thickness. Soil-cement plaster shall be not less than 1 inch (25 mm) thick.
AR104.4.5 Gypsum plaster. Gypsum plaster shall comply with Section 702 of the International Residential Code. Gypsum plaster shall be limited to use on interior surfaces of non-structural walls, and as an interior finish coat over a structural plaster that complies with this appendix.

AR104.4.6 Lime plaster. Lime plaster shall comply with AR104.4.6.1 and AR104.4.6.2.

AR104.4.6.1 General. Lime plaster is any plaster whose binder is comprised of calcium hydroxide (CaOH) including Type N or Type S hydrated lime, hydraulic lime, natural hydraulic lime, or quicklime. Hydrated lime plasters shall comply with ASTM C 206. Quicklime plasters shall comply with ASTM C 5.

AR104.4.6.2 Structural walls. Lime plaster on structural strawbale walls in accordance with Table AR105.14 or Table AR105.15 shall use a binder comprised of hydraulic or natural hydraulic lime.

AR104.4.7 Cement-lime plaster. Cement-lime plaster shall be plaster mixes CL, F, or FL as described in ASTM C 926.

AR104.4.8 Cement plaster. Cement plaster shall comply with Section 702 of the International Residential Code, except that the amount of lime in all plaster coats shall be not less than 1 part lime to 6 parts cement to allow a minimum acceptable vapor permeability. The combined thickness of all plaster coats shall be not more than 1 1/2 inch (38 mm) thick.

AR104.4.9 Prohibited plasters and finishes. Any plaster or finish with a singular or cumulative perm rating less than 5 perms shall be prohibited on straw bale walls, when required elsewhere in this appendix.

AR104.4.10 Separation of wood and plaster. Where wood framing or wood sheathing occurs in exterior strawbale walls, such wood surfaces shall be separated from exterior plaster with No.15 asphalt felt, grade D paper, or other approved material in accordance with Section 703.2 of the International Residential Code, except where the wood is preservative-treated or naturally durable.

Exception: Exterior clay plasters shall not be required to be separated from wood.

SECTION AR105
STRAWBALE WALLS – GENERAL

AR105.1 General. Strawbale walls shall be designed and constructed in accordance with this section.

AR105.2 Finishes. Finishes shall be in accordance with Section AR104.

AR105.3 Sill plates. Sill plates shall support and be flush with each face of the straw bales above and shall be of naturally durable or preservative-treated wood where required by the International Residential Code. Sill plates shall be a minimum of nominal 2 inches by 4 inches with attachment complying with Section R403.1.6 of the International Residential Code and the additional requirements of Tables AR105.4 and AR106.16.

AR105.4 Out-of-plane resistance and unrestrained wall dimensions. Strawbale walls shall employ a method of out-of-plane resistance described in Table AR105.4, and comply with its associated limits and requirements, except where an approved engineered design otherwise demonstrates the wall will resist buckling from superimposed vertical loads and out-of-plane design loads.

AR105.4.1 Determination of out-of-plane loading. Out-of-plane loading shall be determined in accordance with Chapter R301 of the International Residential Code, or in accordance with Chapter 16 of the International Building Code using allowable stress design.

Exception: Out-of-plane loading shall be considered to be no greater than 25 pounds per square foot when all of the following conditions are met.

1. Occupancy category - I or II
2. Seismic design category – A, B, C, or D, as determined by Section 1613.5.6 of the International Building Code
3. Design wind speed – not exceeding 100 miles per hour
4. Stories – not exceeding 2
5. Building height – not exceeding 25 feet
6. Plaster thickness for plastered strawbale walls – not exceeding 2 inches (51mm) each side

Strawbale walls in such structures shall be permitted to use any type of out-of-plane resistance described in Table AR105.4 with the associated limits and requirements.

### TABLE AR105.4: OUT-OF-PLANE RESISTANCE AND UNRESTRAINED WALL DIMENSIONS

<table>
<thead>
<tr>
<th>Method of resistance&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Maximum allowable out-of-plane loading (pounds per square foot)</th>
<th>Unrestrained Wall Dimensions, H&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Mesh Staple Spacing at Boundary Restraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-plaster finish or unreinforced plaster</td>
<td>25</td>
<td>H ≤ 10</td>
<td>none</td>
</tr>
<tr>
<td>Pins per AR105.4.2</td>
<td>25</td>
<td>H ≤ 12</td>
<td>none</td>
</tr>
<tr>
<td>Pins per AR105.4.2</td>
<td>30</td>
<td>H ≤ 10</td>
<td>H ≤ 7T</td>
</tr>
<tr>
<td>Reinforced&lt;sup&gt;c&lt;/sup&gt; clay plaster</td>
<td>30</td>
<td>H ≤ 10</td>
<td>H ≤ 8T&lt;sup&gt;0.5&lt;/sup&gt; (H ≤ 140T&lt;sup&gt;0.5&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Reinforced&lt;sup&gt;d&lt;/sup&gt; clay plaster</td>
<td>30</td>
<td>10 &lt; H ≤ 12</td>
<td>H ≤ 8T&lt;sup&gt;0.5&lt;/sup&gt; (H ≤ 140T&lt;sup&gt;0.5&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Reinforced&lt;sup&gt;e&lt;/sup&gt; cement, cement-lime, lime, or soil-cement plaster</td>
<td>30</td>
<td>H ≤ 10</td>
<td>H ≤ 9T&lt;sup&gt;0.5&lt;/sup&gt; (H ≤ 157T&lt;sup&gt;0.5&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Reinforced&lt;sup&gt;f&lt;/sup&gt; cement, cement-lime, lime, or soil-cement plaster</td>
<td>40</td>
<td>H ≤ 13</td>
<td>H ≤ 9T&lt;sup&gt;0.5&lt;/sup&gt; (H ≤ 157T&lt;sup&gt;0.5&lt;/sup&gt;)</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 pound per square foot = 47.8803 N/m<sup>2</sup>

<sup>a</sup> Finishes applied to both sides of stacked bales. Where different finishes are used on opposite sides of a wall, the more restrictive requirements shall apply.

<sup>b</sup> H = stacked bale height in feet (mm), or the horizontal distance in feet (mm) between vertical restraints. For load-bearing walls, H refers to vertical height only. T = bale thickness in feet (mm).

<sup>c</sup> Plaster reinforcement shall be any mesh allowed in Table AR106.16 for the matching plaster type, but with staple spacing per this table. Mesh shall be installed in accordance with Section AR106.10

<sup>d</sup>Sill plate attachment shall be with 5/8 inch anchor bolts or approved equivalent at a maximum of 48 inches on center where staple spacing is required to be ≤ 4 inches.

**AR105.4.2 Pins.** Pins used for out-of-plane resistance shall comply with the items below or shall be in accordance with an approved engineered design. Pins may be external, internal or a combination of the two.

**AR105.4.2.1 Pins** shall be 3/8 inch (10 mm) diameter steel, 3/4 inch (19 mm) diameter wood, or 1/2 inch (13 mm) diameter bamboo.

**AR105.4.2.2 External pins** shall be installed vertically on both sides of the wall spaced not more than 24 inches (610 mm) on center. External pins shall have full lateral bearing on the sill plate and the top plate or roof- or floor-bearing element, and shall be tightly tied through the wall to an opposing pin with ties spaced not more than 32 inches (762 mm) apart and not more than 6 inches (381 mm) from each end of the pins.

**AR105.4.2.3 Internal pins** shall be installed vertically within the center third of the bales, at spacing not exceeding 24 inches (610 mm) and shall extend from top course to bottom course. The bottom course shall be similarly connected to its support and the top course shall be similarly connected to the roof- or floor-bearing member above with pins or other approved means. Internal pins shall be continuous or shall overlap through not less than one bale course.
AR105.5 Connection of light-frame walls to strawbale walls. Light-frame walls perpendicular to, or at an angle to a straw bale wall assembly, shall be fastened to the bottom and top wood members of the strawbale wall in accordance with requirements for wood or cold-formed steel light-frame walls in the International Residential Code, or the abutting stud shall be connected to alternating straw bale courses with a 1/2 inch (13mm) diameter steel, 3/4” diameter (19 mm) wood, or 5/8” diameter (16 mm) bamboo dowel, with minimum 8 inch (203 mm) penetration.

AR105.6 Moisture control. Strawbale walls shall be protected from moisture intrusion and damage in accordance with AR105.6.1 through AR105.6.7.

AR105.6.1 Water-resistant barriers and vapor permeance ratings. Plastered bale walls shall be constructed without any membrane barrier between straw and plaster to facilitate transpiration of moisture from the bales, and to secure a structural bond between straw and plaster, except as permitted or required elsewhere in this appendix. Where a water-resistant barrier is placed behind an exterior finish, it shall have a minimum vapor permeance rating of 5 perms, except as permitted or required elsewhere in this appendix.

AR105.6.2 Vapor retarders. Wall finishes shall have an equivalent vapor permeance rating of a Class III vapor retarder, except that a Class I or Class II vapor retarder shall be provided on the interior side of exterior strawbale walls in Climate Zones 5, 6, 7, 8 and Marine 4 as defined in Chapter 3 of the International Energy Conservation Code. Bales in walls enclosing showers or steam rooms shall be protected on the interior side by a Class I or Class II vapor retarder.

AR105.6.3 Penetrations in exterior strawbale walls. Penetrations in exterior strawbale walls shall be sealed with an approved sealant or gasket on the exterior side of the wall in all Climate Zones, and on the interior side of the wall in Climate Zones 5, 6, 7, 8 and Marine 4 as defined in Chapter 3 of the International Energy Conservation Code.

AR105.6.4 Horizontal surfaces. Bale walls and other bale elements shall be provided with a moisture barrier at all weather-exposed horizontal surfaces. The moisture barrier shall be of a material and installation that will prevent water from entering the wall system. Horizontal surfaces shall include exterior window sills, sills at exterior niches, and buttresses. The finish material at such surfaces shall be sloped not less than 1 unit vertical in 12 units horizontal (8-percent slope) and shall drain away from all bale walls and elements. Where the moisture barrier is below the finish material, it shall be sloped not less than 1 unit vertical in 12 units horizontal (8-percent slope) and shall drain to the outside surface of the bale’s vertical finish.

AR105.6.5 Bale and concrete separation. A sheet or liquid applied Class II vapor retarder shall be installed between bales and supporting concrete or masonry. The bales shall be separated from the vapor retarder by not less than 3/4 inch (19 mm), and that space shall be filled with an insulating material such as wood or rigid insulation, a material that allows vapor dispersion such as gravel, or other approved insulating or vapor dispersion material. Sill plates in structural walls shall comply with Table AR106.2 and Table AR106.3. Where bales abut a concrete or masonry wall that retains earth, a Class II vapor retarder shall be provided between such wall and the bales.

AR105.6.6 Separation of bales and earth. Bales shall be separated from earth a minimum of 8” (203 mm).

AR105.6.7 Separation of exterior plaster and earth. Exterior plaster applied to straw bales shall be located not less than 4 inches (102 mm) above the earth or 2 inches (51 mm) above paved areas.

SECTION AR106
STRAWBALE WALLS - STRUCTURAL

AR106.1 General. An approved engineered design demonstrating complete vertical and lateral load paths in accordance with this section and the International Building Code shall be provided for buildings or portions thereof that use structural strawbale walls.

Exception: Buildings that use structural strawbale walls complying with the prescriptive structural provisions in Section AR106.17 shall not require an approved engineered design.

AR106.2 Foundations. Foundations shall be in accordance with Chapter 18 of the International Building Code.
AR106.3 Building height and stories. Buildings or portions of buildings constructed with structural strawbale walls shall comply with AR106.3.1 through AR106.3.3

AR106.3.1 Building height shall not exceed 35 feet and the limits contained in Table AR106.14.

AR106.3.2 The number of stories above grade plane shall not exceed two.

AR106.3.2 Structural strawbale walls interrupted by floor assemblies shall be designed and detailed by a registered design professional.

AR106.4 Configuration of bales. Bales in structural walls shall be laid flat or on-edge and in a running bond or stack bond, except that bales in structural walls with unreinforced plasters shall be laid in a running bond only.

AR106.5 Pre-compression of load-bearing strawbale walls. Prior to application of plaster, walls designed to be load-bearing shall be pre-compressed by a uniform load of not less than 100 pounds per linear foot.

AR106.6 Voids and stuffing. Voids between bales in structural strawbale walls shall not exceed 4 inches (102 mm) in width, and such voids shall be stuffed with flakes of straw or straw-clay, before application of finish.

AR106.7 Plaster on structural walls. Plaster on load-bearing walls shall be in accordance with Table AR106.14. Plaster on shear walls shall be in accordance with Table AR106.16.

AR106.7.1 Compressive strength. The building official is authorized to require a 2” cube compression test to demonstrate a minimum compressive strength for plasters on structural walls according to Table AR106.7.1.

TABLE AR106.7.1
MINIMUM COMPRESSIVE STRENGTH FOR STRUCTURAL PLASTERS

<table>
<thead>
<tr>
<th>PLASTER TYPE</th>
<th>MINIMUM COMPRESSIVE STRENGTH (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>100</td>
</tr>
<tr>
<td>Soil-cement</td>
<td>1000</td>
</tr>
<tr>
<td>Lime</td>
<td>600</td>
</tr>
<tr>
<td>Cement-lime</td>
<td>1000</td>
</tr>
<tr>
<td>Cement</td>
<td>1400</td>
</tr>
</tbody>
</table>

AR106.8 Straightness of plaster. Plaster on structural strawbale walls shall be straight, as a function of the bale wall surfaces they are applied to, according to AR106.8.1 through AR106.8.3

AR106.8.1 As measured across the face of a bale, straw bulges shall not protrude more than 3/4 inch (19 mm) across 2 feet (610 mm) of its height or length.

AR106.8.2 As measured across the face of a bale wall, straw bulges shall not protrude from the vertical plane of a bale wall more than 2 inches (51 mm) over 8 feet (2438 mm).

AR106.8.3 The vertical faces of adjacent bales shall not be offset more than 1/2 inch (13 mm).

AR106.9 Plaster and membranes. Structural strawbale walls shall not have a membrane between straw and plaster, or shall have attachment through the bale wall from one plaster skin to the other in accordance with an approved engineered design.

AR106.10 Mesh. Mesh in structural plasters, and where required by Table AR105.4, shall be installed in accordance with AR106.10.1 through AR106.10.3.

AR106.10.1 Mesh laps. Mesh required by Table AR106.14 or Table AR105.4 shall be installed with minimum 4-inch (102 mm) laps. Mesh required by Table AR106.16 shall run continuous vertically from sill plate to the top plate or roof or floor bearing element, or shall lap not less than 8 inches (203 mm). Horizontal laps in such mesh shall be not less than 4 inches (102 mm).
AR106.10.2 Mesh attachment. Mesh shall be attached with staples to horizontal boundary elements in accordance with AR106.10.2.1 through AR106.10.2.3.

AR106.10.2.1 Staples. Staples shall be pneumatically driven, stainless steel or electro-galvanized, 16 gauge with 1 1/2-inch legs, 7/16-inch crown; or manually driven, galvanized, 15 gauge with 7/8-inch legs. Other staples shall be permitted to be used as designed by a registered design professional. Staples into preservative-treated wood shall be stainless steel.

AR106.10.2.2 Staple orientation. Staples shall be firmly driven diagonally across mesh intersections at the required spacing.

AR106.10.2.3. Staple spacing. Staples at the top plate or roof or floor bearing element shall be at a maximum spacing of 2-inches (51 mm) on center or as shown in an approved design in accordance with Section AR106.11. Staples at sill plates shall be at a maximum spacing of 4-inches (102 mm) on center, unless otherwise required by Table AR106.15 or by an approved design in accordance with AR106.11.

AR106.10.3 Steel mesh. Steel mesh shall be galvanized, and shall be separated from preservative-treated wood by grade D paper, 15# roofing felt, or other approved barrier.

AR106.10.3 Mesh in plaster. Required mesh shall be embedded in middle third of the plaster excluding its finish coat, except where staples fasten the mesh to horizontal boundary elements.

AR106.11 Transfer of loads to and from plaster skins. Where plastered strawbale walls are used to support superimposed vertical loads, such loads shall be transferred to the plaster skins by continuous direct bearing or by an approved engineered design. Where plastered strawbale walls are used to resist in-plane lateral loads, such loads shall be transferred to the reinforcing mesh from the structural member or assembly above and to the sill plate in accordance with Table AR106.16, or by an approved engineered design.

AR106.12 Support of plaster skins. Plaster skins for structural strawbale walls shall be continuously supported along their bottom edge. Acceptable supports include: a concrete or masonry stem wall, a concrete slab on grade, a wood-framed floor adequately blocked with an approved engineered design, or a steel angle adequately anchored with an approved engineered design. An unsupported weep screed is not an acceptable support.

AR106.13 Resistance to uplift loads. Where plastered strawbale walls are used to resist uplift loads, such loads shall be transferred to the plaster skins by an approved engineered design. In lieu of an approved engineered design, plaster mesh in skins complying with Table AR106.16, with staples at 2 inches (51 mm) on center, and with associated sill plate and anchoring requirements, shall be considered capable of resisting uplift loads not associated with in-plane shear resistance, of 200 plf (2,918 N/m) per plaster skin.

AR106.14 Load-bearing strawbale walls. Load-bearing strawbale walls shall be in accordance with Table AR106.14 as part of an approved engineered design to support superimposed vertical loads. Concentrated loads shall be distributed by structural elements capable of distributing the loads to the bearing wall within the allowable bearing capacity limits in AR106.14. The allowable bearing capacity values in Table AR106.14 are in accordance with allowable stress design.

**TABLE AR106.14**

<table>
<thead>
<tr>
<th>WALL DESIGNATION</th>
<th>PLASTER (both sides) Minimum thickness each side</th>
<th>MESH&lt;sup&gt;b&lt;/sup&gt;</th>
<th>STAPLES&lt;sup&gt;c&lt;/sup&gt;</th>
<th>ALLOWABLE BEARING CAPACITY&lt;sup&gt;d&lt;/sup&gt; (plf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Clay 1-1/2”</td>
<td>None required</td>
<td>None required</td>
<td>400</td>
</tr>
<tr>
<td>B</td>
<td>Soil-cement 1”</td>
<td>required</td>
<td>required</td>
<td>800</td>
</tr>
<tr>
<td>C</td>
<td>Lime 7/8”</td>
<td>required</td>
<td>required</td>
<td>500</td>
</tr>
<tr>
<td>D</td>
<td>Cement-lime</td>
<td>required</td>
<td>required</td>
<td>800</td>
</tr>
</tbody>
</table>
### WALL DESIGNATION | PLASTER² (both sides) | MESHᵇ | STAPLESᶜ | ALLOWABLE BEARING CAPACITYᵈ (plf)
--- | --- | --- | --- | ---
E | 7/8" | required | required | 800

For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. Plasters shall conform with Sections AR104.4.3 through AR104.4.8, AR106.7, AR106.8, and AR106.12.
b. Any metal mesh allowed by this appendix and installed in accordance with Section AR106.10.
c. In accordance with Section AR106.10.2, except as required to transfer roof or floor loads to the plaster skins in accordance with Section AR106.11.
d. For walls with a different plaster on each side, the lower value shall be used.

### AR106.15 Design coefficients and factors for seismic design. The values in Table AR106.14 shall apply to seismic design using strawbale shear walls detailed in accordance with Table AR106.16.

### AR106.16 Strawbale shear walls. Strawbale shear walls shall be in accordance with Table AR106.16 as part of an approved engineered design to resist in-plane lateral loads. Components of strawbale shear walls shall also comply with AR106.16.1 through AR106.16.3. The allowable shear values in Table AR106.16 are in accordance with allowable stress design. Design shear wall deflection is not more than .0035 times the wall height at the allowable shear wall limits. Other approved in-plane lateral load resisting systems shall be permitted for use in combination with strawbale shear walls with apportionment of design loads as prescribed in the International Building Code.

#### AR106.16.1 Bale thickness. Bale thickness shall not be less than 15 inches (3810 mm).

#### AR106.16.2 Sill plates. Sill plates shall be in accordance with Table AR106.16.

#### AR106.16.3 Sill plate fasteners. Sill plates shall be fastened with minimum 5/8-inch (16 mm) diameter steel anchor bolts with 3-inch by 3-inch by 3/16-inch steel washers, with not less than 7-inch embedment in a concrete or masonry foundation, or shall be an approved equivalent. Anchor bolts or other fasteners into framed floors shall be of an approved engineered design.

### TABLE AR106.15
**DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC-FORCE-RESISTING SYSTEMS**

<table>
<thead>
<tr>
<th>Seismic-Force-Resisting System</th>
<th>Response Modification Coefficient, Rᵃ</th>
<th>System Overstrength Factor, Omegaᵇ</th>
<th>Deflection Amplification Factor, Cᵈ</th>
<th>Structural System Limitations and Building Height (ft) Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Bearing Wall Systems</td>
<td></td>
<td></td>
<td></td>
<td>Seismic Design Category B C D E F</td>
</tr>
<tr>
<td>Strawbale shear walls</td>
<td>3.5</td>
<td>3</td>
<td>3</td>
<td>25 25 15 15 NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural System Limitations and Building Height (ft) Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Design Category B C D E F</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>25 25 15 15 NA</td>
</tr>
</tbody>
</table>

⁽ᵃ⁾ R reduces forces to a strength level, not an allowable stress level
⁽ᵇ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.

### TABLE AR106.16
**ALLOWABLE SHEAR (POUNDS PER FOOT) FOR PLASTERED STRAWBALE SHEAR WALLS**

<table>
<thead>
<tr>
<th>WALL DESIGNATION</th>
<th>PLASTER² (both sides)</th>
<th>SILL PLATESᵇ (nominal size in inches)</th>
<th>ANCHOR BOLTᶜ SPACING (on center)</th>
<th>MESHᵈ</th>
<th>STAPLE SPACINGᵉ (on center)</th>
<th>ALLOWABLE SHEARᶠ (plf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>THICKNESS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁽ᵃ⁾ R reduces forces to a strength level, not an allowable stress level
⁽ᵇ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.

⁽ᶜ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.

⁽ᵈ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.

⁽ᵉ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.

⁽ᶠ⁾ The tabulated value of the overstrength factor is permitted to be reduced by subtracting 0.5 for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.
### AR106.17 Prescriptive design for plastered structural strawbale walls

Plastered strawbale walls shall be permitted to be used structurally without an approved engineered design, when such walls comply with Sections AR106.17.1, AR106.17.2, and AR106.17.3.

#### AR106.17.1 Loads and other limitations

Loads and other limitations shall be in accordance with Section R301 of the *International Residential Code*. Strawbale wall dead loads shall not exceed 60 psf (2872 N/m²).

#### AR106.17.2 Load-bearing walls

Load-bearing walls shall be limited to use in one-story and two-story buildings, and to wall types B, C, D, and E in Table AR106.14, except that type A walls shall be permitted where they are demonstrated to support design loads no greater than the allowable load indicated in Table AR106.14.

#### AR106.17.3 Braced panels

Plastered strawbale walls shall be permitted to be used as braced wall panels for one-story and two-story buildings in accordance with Sections R602.10 and R602.11 of the *International Residential Code*. Strawbale shear panel types B, C2, D2, and E as defined in Table AR106.16 shall be considered equivalent to Method WSP for wind bracing and Methods DWB, SFB, GB, PBS, PCP or HPS for seismic bracing. Strawbale shear panel Types A, C1 and D1 shall be considered equivalent to Method GB for wind and seismic bracing.

#### AR106.17.4 Foundations

Foundations for plastered strawbale walls shall be in accordance with Chapter 4 of the *International Residential Code*.

### SECTION AR107

**FIRE RESISTANCE**

<table>
<thead>
<tr>
<th>(minimum, each side)</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B</th>
<th>C1</th>
<th>C2</th>
<th>D1</th>
<th>D2</th>
<th>E1</th>
<th>E2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clay</strong></td>
<td>1.5&quot;</td>
<td>1.5&quot;</td>
<td>1.5&quot;</td>
<td>1&quot;</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
<td>1.5&quot;</td>
</tr>
<tr>
<td><strong>2 x 4</strong></td>
<td>32&quot;</td>
<td>32&quot;</td>
<td>32&quot;</td>
<td>24&quot;</td>
<td>32&quot;</td>
<td>24&quot;</td>
<td>32&quot;</td>
<td>24&quot;</td>
<td>24&quot;</td>
<td>4 x 4</td>
</tr>
<tr>
<td><strong>2&quot; x 2&quot; high-density polypropylene</strong></td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td><strong>None</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>17 ga woven wire</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
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<td>2&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td><strong>60</strong></td>
<td>140</td>
<td>180</td>
<td>520</td>
<td>330</td>
<td>450</td>
<td>380</td>
<td>520</td>
<td>540</td>
<td>680</td>
<td>60</td>
</tr>
</tbody>
</table>

**Notes:**

- Plasters shall conform with Sections AR104.4.3 through AR104.4.8, AR106.7, AR106.8, and AR106.12.
- Sill plates shall be Douglas fir-larch or southern pine and shall be preservative-treated where required by the *International Building Code*.
- Multiply allowable shear value by .82 for other species with specific gravity of .42 or greater, or by .65 for all other species.
- Anchor bolts shall be in accordance with Section AR106.16.3 at the spacing shown in this table.
- Installed in accordance with Section AR106.10.
- Staples shall be in accordance with Section AR106.10.2 at the spacing shown in this table.
- Values shown are for aspect ratios of 1:1 or less. Reduce values shown to 50% for the limit of a 2:1 aspect ratio. Linear interpolation shall be permitted for aspect ratios between 1:1 and 2:1. The full value shown shall be used for aspect ratios greater than 1:1, where an additional layer of mesh is installed at the base of the wall to a height where the remainder of the wall has an aspect ratio of 1:1 or less, and the second layer of mesh is fastened to the sill plate with the required stapling, and the sill bolt spacing is decreased with linear interpolation between 1:1 and 2:1.
- For walls with a plaster Type A on one side and any other plaster type on the other side, a registered design professional shall show transfer of the design lateral load into the stiffer Type B, C, D, or E plaster only, and 50% of the allowable shear value shown for that wall designation shall be used.
- These values are permitted to be increased 40 percent for wind design.
- 16 gauge mesh shall be permitted to be used with a reduction to 0.60 of the allowable shear values shown.
AR107.1 Fire-resistance rating. Strawbale walls shall be considered to be non-rated, except for walls constructed in accordance with Section AR107.1.1 or AR107.1.2. Alternately, fire-resistance ratings of strawbale walls shall be determined in accordance with Section R302 of the International Residential Code.

AR107.1.1 1-hour rated clay plastered wall. 1-hour fire-resistance-rated non-load-bearing clay plastered strawbale walls shall comply with AR107.1.1.1 through AR107.1.1.5.

AR107.1.1.1 Bales shall be laid flat or on-edge in a running bond.

AR107.1.1.2 Bales shall maintain thickness of not less than 18 inches (457 mm).

AR107.1.1.3 Gaps shall be fire-stopped with straw-clay.

AR107.1.1.4 Clay plaster on each side of the wall shall be not less than 1 inch (25 mm) thick and shall be comprised of a mixture of 3 parts clay, 2 parts chopped straw, and 6 parts sand, or an alternative approved clay plaster.

AR107.1.1.5 Plaster application shall be in accordance with AR104.4.3.3 for the number and thickness of coats.

AR107.1.1.6 Bales shall maintain thickness of not less than 14 inches (356 mm).

AR107.1.2 2-hour rated cement plastered wall. 2-hour fire-resistance-rated non-load-bearing cement plastered strawbale walls shall comply with AR107.1.2.1 through AR107.1.1.6.

AR107.1.2.1 Bales shall be laid flat or on-edge in a running bond.

AR107.1.2.2 Bales shall maintain a thickness of not less than 14 inches (356 mm).

AR107.1.2.3 Gaps shall be fire-stopped with straw-clay.

AR107.1.2.4 1 1/2 inch (38 mm) by 17 gauge galvanized woven wire mesh shall be attached to wood members with 1 1/2 inch (38 mm) staples at 6 inches (406 mm) on center. 9 gauge U-pins with minimum 8 inch (203 mm) legs shall be installed in the field at 18 inches (457 mm) on center.

AR107.1.2.5 Cement plaster on each side of the wall shall be not less than 1 inch (25 mm) thick.

AR107.1.2.6 Plaster application shall be in accordance with AR104.4.8 for the number and thickness of coats.

AR107.2 Openings in rated walls. Openings and penetrations in bale walls required to have a fire-resistance rating shall satisfy the same requirements for openings and penetrations as prescribed in the International Residential Code.

AR107.3 Clearance to fireplaces and chimneys. Strawbale surfaces adjacent to fireplaces or chimneys shall be finished with a minimum 3/8 inch (10 mm) thick plaster of any type permitted by this appendix. Clearance from the face of such plaster to fireplaces and chimneys shall be maintained as required from fireplaces and chimneys to combustibles in Chapter 10 of the International Residential Code, or as required by manufacturer’s installation instructions, whichever is more restrictive.

SECTION AR108
THERMAL INSULATION

AR108.1 R-value. The unit R-value of a strawbale wall with bales laid flat is R-1.3 per inch of bale thickness. The unit R-value of a strawbale wall with bales on-edge is R-2 per inch of bale thickness.